STATEMENT OF BASIS
CDOT Region 6 Headquarters Site
2000 South Holly
Denver, CO
EPA #CO5000-04976

Harding Lawson Associates (HLA), on behalf of their client, the Colorado Department of Transportation (CDOT), proposes to inject nutrients (ammonium nitrate and potassium phosphate), oxygen releasing compound, and a co-metabolic food source as part of a three-month duration, in-situ, biodegradation, pilot-scale test for a remediation program. The test will evaluate the effectiveness of these constituents on stimulating bioactivity to degrade methylene chloride, 1,1-dichloroethene (1,1-DCE), trichloroethene (TCE), and tetrachloroethene (PCE). The injection of oxidizing agents has been successful in degrading chlorinated hydrocarbons at the Solar Mall site in Colorado Springs and at the Redfield Facility, which is downgradient from this site. The injection of nutrients has been successful in treating hydrocarbons at several LUST remediation sites in Region 8. This pilot test is the first time the Class V program in Region 8 has encountered the injection of constituents in combination to address both aerobic and anaerobic bacteria populations. The anticipated start-up time for the pilot-scale injection is January, 2000.

Background

The source area for the contaminants is believed to be a former dry well, approximately 12 inches in diameter and 11 feet deep, located next to the Materials Laboratory at the CDOT Region 6 Headquarters Facility. The site is located northeast of the intersection of East Evans and South Holly Street. The well consisted of a corrugated pipe filled with coarse gravel. The well was believed to have been used for the disposal of methylene chloride/asphalt cement solution sometime during the time frame between 1966 and the mid 1970's. The well was removed and abandoned by Harding Lawson Associates/Layne Western on December 21-22, 1998.

Hydrogeologic Information

The geologic strata underlying the site include surficial materials and bedrock strata of the Denver Formation. The surface material consists of unconsolidated deposits of Pleistocene loess ranging in thickness from 13 to 18 feet. Based on boring logs, the loess overburden consists predominantly of light to dark brown, non-stratified, sandy clay with localized deposits of silty clay and very fine to fine-grained, clayey sand.

The uppermost bedrock formation beneath the study area is the Late Cretaceous to Early Tertiary Denver Formation. Based on boring logs, the Denver Formation consists predominantly of claystone and siltstone with interbedded and interfingering thin, lenticular sandstones and local, thick channel sandstones. Two channel sandstone units have been identified. These units have been designated the A and B sandstones. The A sandstone is the shallowest sandstone encountered beneath the former dry well area, occurring at a depth of approximately 15 to 30 feet below ground surface. At this site it actually consists of two thin sandstones that are locally

continuous. The sandstones are very fine to fine-grained and are generally silty to clayey. The lower B sandstone unit is a relatively thick sandstone occurring at a depth of approximately 35 to 55 feet below ground surface. The A and B sandstones are separated by a claystone interval or approximately 2 to 5 feet in thickness. The B sandstone appears to be more laterally continuous beneath the study area than the A sandstone. The upper portion of the B sandstone consists of very fine to fine-grained, uncemented sand with interbedded siltstone or thin claystone stringers. The lower portion is coarse-grained at the base to fine-grained near the top, is micaceous and alternates from uncemented to cemented with uncemented zone friable and wet. Cross-bedding has been noted near the base of the unit.

In the area of the former dry well the groundwater level is approximately 18 feet below ground surface, which is below the Denver Formation/overburden contact. This water level was established during a March/April, 1999, monitoring event for the study area. From that data, a contour map was constructed, indicating a northeast gradient to the groundwater surface that slopes approximately 0.047 foot/foot. The groundwater flow is northeast toward the Redfield Riflescopes Facility. Aquifer tests performed in the dry well area to assess the hydraulic properties of the A and B sandstones provided hydraulic conductivity values of 3.15×10^{-5} cm/sec for the A sandstone and 8.7×10^{-5} cm/sec for the B sandstone. Flow rates observed during the aquifer tests were 0.016 gal/min from the upper zone, and 0.039 gal.min from the lower zone. The horizontal groundwater flow velocity in the A sandstone was estimated at 9 to 18 feet per year using the previously stated hydraulic conductivity, the previously stated hydraulic gradient, and an effective porosity of 8.5%. The horizontal groundwater flow velocity in the B sandstone was estimated at 39 feet per year, using the previously stated hydraulic conductivity, the previously stated hydraulic gradient, and an effective porosity of 11%.

Injectate and Injection Scheme

The injectate will consist of ammonium nitrate and potassium phosphate in concentrations of approximately 50 mg/L and 5 mg/L respectively, hydrogen peroxide in concentrations ranging from 100 mg/L to as high as 800 mg/L, and methane. Methane will be added to the injection stream near the end of the startup period. A rate of approximately 0.39 cubic inches of methane per gallon of injected water will be regulated with a pressure regulator and valves, so that the approximate ratio of methane is delivered to the process water stream. A static mixer will be located in the treatment system immediately downstream of the injection port to thoroughly mix the solution.

The injection will be through two injection wells, one completed in the A sandstone located near the former dry well, the second completed in the B sandstone near abandoned well C-MW11. The injection well in the A sandstone will be located at the western end of the plume with a monitoring well located 5 feet downgradient. The injection well in the B sandstone will be located within the plume, in the zone of highest concentration of methylene chloride. The monitoring well will be located about 7 feet downgradient from the injection well. Based on calculated flow rate, the injectate will reach the downgradient monitoring wells

A - 9 ft/yr - 6.7 months to get to downgradient well 5 ft away
18 ft/yr - 3 months to get to downgradient well 5 ft away
B - 39 ft/hr - 2 months to get to downgradient well 7 ft away
Although the downgradient monitoring wells are close to the point of injection, it is the contact time with the contaminant that influences the degradation of the contaminant. The groundwater moves very slowly within these aquifers. These monitoring wells are located close enough to have the injectate front reach them near the completion date of the pilot test so the effect of the injectate constituents can be evaluated soon after the completion of the injection activities. The anticipated combined injection rate will be about 0.05 gal/min for the upper and lower zone injection wells. An injection pressure step-test will be run to test injection initially at 5 psi and increasing by 5-psi increments to 10 psi and 15 psi.

Drinking Water Wells and Surface Water Features near Site

There are no private or public water supply drinking water wills within or near the plume area that are completed in the same aquifer interval. The nearest domestic well is 1/8 to1/4 mile west of the site, but it is completed at a depth of about 150 feet.

Cherry Creek is located approximately 1 mile northeast of the site.

Responsible Party

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Recommendation

The background level of nitrate in the groundwater was analyzed in two monitoring wells completed in the B sandstone, C-MW16S and C-MW17D. These two values were 16.1 and 15.7 mg/l of nitrate as N respectively. C-MW16S is located within the methylene chloride plume and the C-MW17D is located outside of the plume as shown in attached fig 2. Based on the comparison of these two nitrate values, it does not appear that biodegradation is reducing the level of nitrate within the plume at this time, but only two nitrate values are not conclusive. Because the background level of nitrate is already above the MCL of 10 mg/L, nitrate levels should be monitored in the monitoring wells located downgradient from each of the injection wells. Samples will be collected from two downgradient monitoring wells in the upper zone and one upgradient and one downgradient well in the lower zone biweekly for 3 months after injection begins and semi-monthly from 4 to 6 months after injection begins, as shown in attached table B1. This should provide adequate information about levels of nitrate resulting from injection activities

Notes from phone conversation on 11-17-99:
The background nitrate values are still high within the methylene chloride plume, because the

bacteria that would utilize it in the bioremediation process are thought to be competing with aerobic bacteria populations, and are, therefore, not fully utilizing the available nitrate. The addition of phosphate and carbon via the methane, which are needed by both populations, should boost the usage of nitrate.

Injection well in upper unit will be screened from the water table down to the bottom of the lower sandstone unit of the A sandstone. Upper zone monitoring well C-MW29A will be screen across both upper and lower A. The other monitoring well is screened only in the lower A sandstone

Injection pressure will be determined by test. Expected to be 10 psi max.

The injection rate of 0.05 gpm is the injection rate into both the A and B sandstone units combined.

The groundwater study was done in April/March, 1999. The groundwater velocity is not expected to vary significantly seasonally. The injection will not have a significant effect on the flow rate.

Addendum to Statement of Basis
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The decision to inject nutrients (ammonium nitrate and potassium phosphate), oxygen releasing compound, and a co-metabolic food source as part of a three-month duration, in-situ, biodegradation, pilot-scale test at this site was based on the results of a treatability study. The treatability study was performed on contaminated water from the site as a laboratory bench scale test to determine what microbial populations were present and what agents could be added to enhance bioremediation at the site. The results of the treatability study indicated that:

- The existing microbial population contains a subpopulation of methylene chloride-utilizing microorganisms within a range acceptable for biological degradation.
- The existing groundwater pH and the nutrient nitrogen levels in groundwater could limit the effectiveness of biological degradation of methylene chloride.
- The addition of nutrients and oxygen enhanced the growth of the methylene chloride-utilizing microbial population and high concentrations of methylene chloride were reduced rapidly and effectively in the laboratory.

This pilot test is the next level of verification of the lab scale results before deciding whether this method will be successful as a full scale remediation strategy. The test injections will be located in the highest concentration portion of the plume, and will be conducted under the "worst-case scenario." Therefore, positive results should be definitive.

It should be noted that methylene chloride is the contaminate of the highest concentration at the site. Other chlorinated organics are present, but in much lower concentrations. The methylene chloride chemical structure is readily amenable to biodegradation. The other constituents [1,1-dichloroethene (1,1-DCE), trichloroethene (TCE), and tetrachloroethene (PCE)] are more difficult to degrade, but this pilot test is also designed to test effectiveness of the co-metabolism of these lesser constituents. The injectate includes constituents that should enhance this co-metabolism.

Other remediation technologies are being considered, such as excavation of the hosting aquifer material and air sparging. The decision to conduct this injection pilot test scale was made in conjunction with CDPHE RCRA staff, because it appeared to be the most promising based on the treatability study, and the quickest strategy to achieve compliance with MCLs at the property boundary, a condition of the consent order at this site. This injection strategy is also being considered for use at another CDOT site, located at Louisiana and Colorado, where methylene chloride is present in the groundwater. An exhaustive evaluation of available remediation technologies was performed for the Louisiana and Colorado site. Based on this evaluation,

injection technology was selected for pilot testing at the South Holly site.

MODIFICATION TO
STATEMENT OF BASIS
July 20, 2000

Based on conversation with Paul Weaverling at HLA, the results of the pilot study to date have shown favorable results in reducing contaminant levels within the plume. HLA is proposing to CDPHE to use this injection strategy as the long term remediation method. HLA is requesting an extension of the pilot test injection in order the maintain the steady-state of the nutrient injection plume and level of microbial activity that has been developed over the past 6 months. The pilot test injection has achieved a stable hydraulic head of the nutrient plume within the formations being remediated. If injection ceases at the end of the 6 month pilot test as originally planned, the nutrient injectate will be consumed by the microbial activity that is actively reducing the contaminant levels within the aquifer. As a result the injectate plume fronts will be lost and the project will have to regain the progress made to date in establishing a nutrient plume within the formation.

Recommendation: Approval of the extension of the pilot test injection in order to maintain the level of microbial activity until the final remediation strategy can be put into place will be beneficial in reducing the contaminant level more efficiently in the long term, allow continued maintenance of the injectate plume and present level of microbial activity, and will not cause any negative impact to groundwater.

Addendum to Statement of Basis
for Rule Authorization Modification
CDOT Region 6 Headquarters Site
2000 South Holly
Denver, CO
EPA #CO5000-04976
December 22, 2000

Summary of Previous Background Info: In November, 1999, Harding ESE proposed to conduct a pilot-scale test to assess whether an active aerobic biodegradation process can be effectively implemented in a complex hydrogeologic setting to remove methylene chloride from groundwater in the Dry Well area of the CDOT Region 6 Headquarters Site at 2000 South Holly Street in Denver. A secondary purpose was to assess the potential of the pilot-scale test to stimulate cometabolic degradation of more highly chlorinated compounds present in groundwater such as PCE, TCE, 1,1 DCE.

A bench-scale treatability study indicated that enhanced aerobic and anaerobic biological treatment were technically feasible and effective for reducing methylene chloride concentrations in samples of soil and groundwater collected from the Dry Well area. Conclusions of the laboratory study are that

- The existing microbial population in the soil samples from the Dry Wells area contains a subpopulation of methylene chloride-utilizing microorganisms and this subpopulation is within a range acceptable for biological degradation.
- In situ groundwater pH and the nitrogen concentration could limit the enhancement of biological degradation of methylene chloride unless they are chemically controlled.
- The addition of the nutrients and oxygen enhanced the growth of the methylene chloride-utilizing microbial populations, producing a 99.999 % decrease in methylene chloride concentration during the 58-day incubation period. The enhancement of anaerobic growth conditions resulted in a 99.9 % decrease in methylene chloride concentration during the 58-day incubation period.

The specific objectives of the pilot-scale test conducted in the Dry Well area were to:

- Assess whether the conditions conducive to stimulating the methylene chloride-utilizing microbial population can be created in groundwater flow systems beneath the Site, (e.g., could nutrient-enriched injection water be successfully injected into the formation).
- Evaluate impacts to the groundwater gradient and rate of the treatment front breakthrough in the formation at downgradient monitoring points (e.g., could nutrient-enriched injection water be propagated through the formation.
- Evaluate the effects of injected nutrient and oxygen on the microbial process with respect to the biodegradation of methylene chloride and higher chlorinated solvents.

The pilot-test system operation began on January 31, 2000, and continued through July 21, 2000. Harding ESE submitted a report of the pilot-scale monitoring results on September 20,

2000. CDOT requested a 6-month extension of the Rule Authorization in July, 2000, in order to continue injection activities and maintain the steady-state of the permeation of nutrients throughout the plume to maintain the level of microbial activity that had been developed during the pilot test. The 6 month extension of injection activity provided for continuation of injection and monitoring activity through January 31, 2001, covering the period of time required for development of the Corrective Measures Work Plan. The Work Plan will be submitted to CDPHE on December 22, 2000, meeting the CDPHE deadline of December 28, 2000.

Rule Authorization Modification: On December 18, 2000, Harding ESE requested another extension of injection activities until July 31, 2001, to cover the time period for CDPHE review of the Corrective Measures Work Plan and a 30-day public comment period on the proposed preferred remedy. Based on the success of the pilot test, the in-situ biodegradation of the contaminated is the proposed preferred remedy for final remediation. This extension should maintain the biodegradation system until the final remedy can be implemented. At that time Harding ESE will probably request a new Rule Authorization for large scale injection activity.

Analytical results for the contaminants of concern in the source area are shown in the table below This well was measured again in November, 2000, during the Rule Authorization extension period, when the concentration of methylene chloride measured 21 ppb. Nitrate analysis was also of concern, because of the injection of nutrients containing about 50 mg/l nitrate. By the end of the pilot test all monitoring wells were below the MCL for nitrate. All analytical results are attached to this statement.

Contaminant	**concentration before pilot test (12-1-1999) ppb**	**concentration July 27, 2000 ppb**	**MCL ppb**
methylene chloride (dichloromethane)	2,6000,000	30,000	5
trichloroethene TCE	1,400	73	5
tetrachloroethene PCE	1,000	33	5
1,1 dichlorothethene 1,1 DCE	670	3	7
vinyl chloride	4	<2	2

Recommendation: As was recommended in July, 2000, approval of another extension of the pilot test injection in order to maintain the level of microbial activity until the final remediation strategy can be put into place will be beneficial in reducing the contaminant level more efficiently

in the long term, allow continued maintenance of the injectate plume and present level of microbial activity, and will not cause any negative impact to groundwater. Allowing the injection activities to continue will enable further reduction of contaminate concentrations. The following table shows the decrease in concentrations of contaminants of concern during the original pilot-test timeframe.